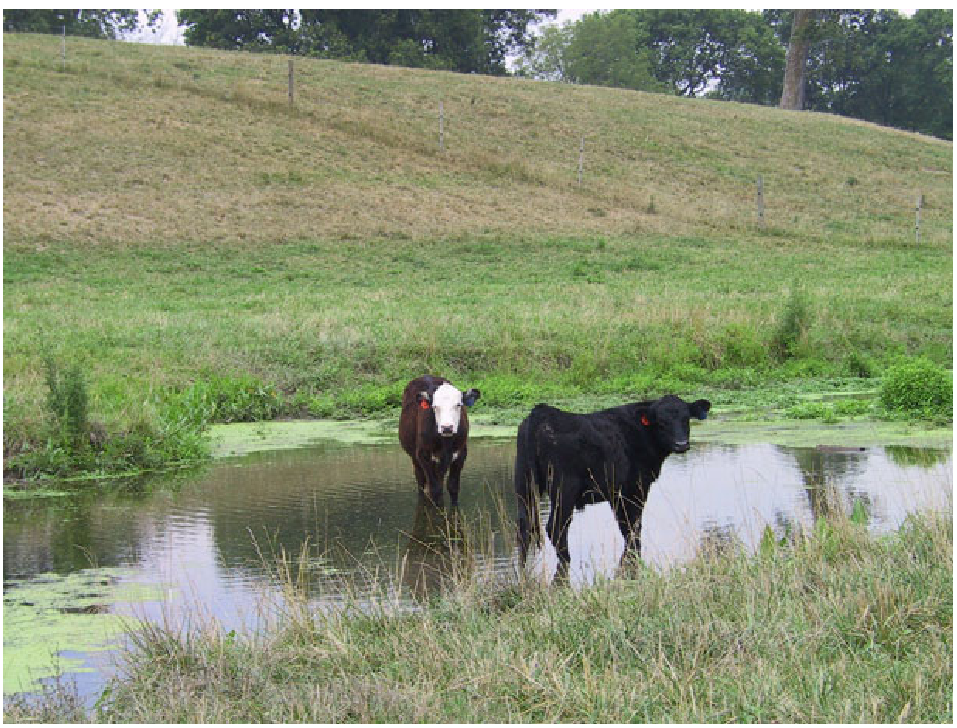
PROTOCOL
FOR
MONITORING EFFECTIVENESS
OF
RIPARIAN LIVESTOCK EXCLUSION
PROJECTS

MC-4

Washington Salmon Recovery Funding Board

April 2004



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ORGANIZATION

This document details the monitoring design, procedures, and quality assurance steps necessary to document and report the effectiveness of:

- **Livestock exclusion fencing**

This document is in compliance with the Washington Comprehensive Monitoring Strategy (Crawford et al. 2002).

Livestock exclusions have the potential to create improvements in bank stabilization, streamside shading, erosion control, and other benefits in a moderate time (5-20 years).

The goal of livestock exclusion fencing is to exclude cattle from the riparian area of the stream where they can cause severe damage to the stream by breaking down stream banks and increasing erosion, destroying shade producing trees and shrubs, and increasing sedimentation. By excluding cattle with fencing, these adverse impacts can be avoided and restoration of the shoreline can occur.

MONITORING GOAL

Determine whether livestock exclusion projects are effective in excluding livestock, restoring riparian vegetation and restoring stream bank stability.

QUESTIONS TO BE ANSWERED

Are livestock excluded from the riparian area?

Has riparian vegetation been restored in the impact area?

Has bank erosion been reduced in the impact area?

NULL HYPOTHESIS

Exclusion of livestock from the riparian corridor has had no significant effect upon:
- Increasing the amount of shading.
- Increasing the complexity of canopy layers of streamside riparian cover.
- Reducing the proportion of actively eroding streambanks.

OBJECTIVES

BEFORE PROJECT OBJECTIVES (YEAR 0)

Determine overall use by livestock of the riparian area to be excluded.

Determine the total acreage to be fenced.

Determine the total kilometers of stream protected.

Determine the overall riparian vegetation cover layers and percent shading within the project area.

Determine the overall proportion of stream bank actively eroding.

POST-PROJECT OBJECTIVES (YEARS 1, 3, 5, AND 10)

Determine the overall use by livestock of the riparian area excluded.

Determine the overall riparian vegetation cover layers and percent shading within the project area.

Determine the overall proportion of stream bank actively eroding.

RESPONSE INDICATORS

Level 1--Exclusion Effectiveness. The presence or absence of livestock inside the exclusion can be used as a measure of the effectiveness of the fencing design in excluding livestock from the riparian area.

Indicator Abbreviation	Description
EXCLDESIGN	The number of livestock exclusions meeting the design criteria for excluding livestock from the stream
LVSTOCKAREA	The area excluded with fencing

Level 2-- Riparian Indicators. Using EMAP protocols (Peck et al. Unpubl.), the percent shading (using a densitometer) is a metric that can be determined in a consistent manner. This metric was chosen because it has been shown to have one of the highest signal to noise ratios (17) of 18 different parameters measured involving riparian vegetation. Using EMAP protocols, the percent of riparian area containing all three layers of vegetation, canopy layer (.5m high), understory (0.5 to 5m high), and ground cover (,0.5m high). This metric was chosen because it has been shown to have one of the highest signal to noise ratios (8) of 18 different parameters measured involving riparian vegetation. Using ODFW methods outlined on page 16, the proportion of actively eroding streambanks can be determined within the sampled stream reaches.

Riparian vegetation variables

Indicator Abbreviation	Description
XCDENBK	Mean percent shading at the bank (using a densitometer)
XPCMG	Proportion of the reach containing all 3 layers of riparian vegetation, canopy cover, under-story, and ground cover
BANK	Proportion of the reach containing actively eroding stream banks
STRMLGTH	Affected stream length includes meander length affected by the project
CREACHLGTH	The length of the stream control reach actually sampled
IREACHLGTH	The length of the stream Impact reach actually sampled

MONITORING DESIGN

The Board will employ a Before and After Control Impact (BACI) experimental design to test for changes associated with livestock exclusions (Stewart-Oaten et al. 1986). A BACI design samples the control and impact simultaneously at both locations at designated times before and after the impact has occurred. For this type of restoration, placing livestock exclusions would be the impact, that is, the location impacted by the restoration action, and a location upstream of the livestock exclusion would represent the control.

For riparian vegetation and actively eroding streambanks, the BACI design tests for changes at the livestock exclusion impact reach *relative to* the changes in riparian vegetation and actively eroding streambanks observed at a control site upstream. This type of design is required when external factors (e.g., soils, rainfall) affect the riparian vegetation and actively eroding streambanks at the control site. The object is to see whether the difference between upstream (control) and downstream (impact) riparian vegetation and actively eroding streambanks has changed as a result of the livestock exclusion projects. The presence of multiple projects with control and impact locations will address the concerns detailed by Underwood (1994) regarding pseudoreplications. It is also not considered cost effective to employ multiple control locations for each passage project as recommended by Underwood. Although the ideal BACI would have multiple years of before data as well as after data, this was not possible with locally sponsored projects where there is a need and desire to complete their project as soon as possible.

The plan is to compare the most recent time period of sampling with Year 0 conditions, before the projects. A paired *t*-test will be used to test for differences between control (upstream) and impact (downstream) sites during the most recent impact year and Year 0. In other words, we first compute the difference between the control and impact and use those values in a paired *t*-test. This test assumes that differences between the control and impact sites are only affected by the placing of a livestock exclusion and that external influences affect riparian vegetation and actively eroding streambanks in the same way at both the control and impact sites. The paired sample *t*-test does not have the same assumptions for normality and equality of variances of the two-sample *t*-test but only requires that the differences be approximately normally distributed. In fact, the paired-sample test is really equivalent to a one-sample *t*-test for a difference from a specified mean value.

To implement the design, we will monitor livestock exclusion projects funded in Round 4, 5, and 6 beginning in 2004 until 10 total projects can be tested for effectiveness. If there are insufficient projects funded in any one year to obtain a proper sample size, then replicates of the design will be used in multiple years until the critical sample size is reached.

The variance associated with impact and control areas will not be known until sampling has occurred in Year 0 of both impact and control areas. After Year 0, a better estimate of the true sample size needed to detect change will be available. Cost estimates and sampling replicates may need to be adjusted at that time.

At the end of the effectiveness monitoring testing, there will be one year of “Before” impact information for all projects for both control and impact areas, and multiple years of “After” impact information for the same control and impact areas for each of the projects. Depending upon circumstances, the results may also be tested for significance, using a linear regression model of the data points for each of the years sampled and for each of the indicators tested.

Testing for significant trends can begin as early as Year 1. Final sampling may be completed in 2014.

DECISION CRITERIA

Effective if design criteria are met for 80% or more of the structures by Year 10.

Effective if a change of 20% or more is detected in the calculated difference of the mean percent canopy density, the proportion of actively eroding stream banks, and the proportion of the three layers of riparian vegetation between the paired impact and control areas by Year 10 or earlier at the Alpha =0.10 level.

Table 1. Decision criteria for livestock exclusions

Habitat	Indicators	Metric	Test Type	Decision Criteria
Livestock exclusion fencing	The number of livestock exclusions meeting the design criteria for excluding livestock from the stream (EXCLDESIGN)	#	None. Count of functional exclusions	≥ 80% of exclusions are functional by Year 10. “Functional” means there are no holes in the fencing and no recent signs of livestock inside the exclusion.
Riparian Condition	Mean percent canopy density at the bank Densitometer Reading (XCDENBK)	1-17 score	Linear Regression or Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between Impact and control by Year 10
	3-layer riparian vegetation presence (proportion of reach) (XPCMG)	%	Linear Regression or Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between Impact and control by Year 10
	Actively eroding banks (BANK)	%	Linear Regression or Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between Impact and control by Year 10

SAMPLING

We wish to determine whether the fencing exclusion has been effective in excluding cattle and in restoring riparian vegetation. The entire impact area should be surveyed, if sufficiently small.

SELECTING SAMPLING REACHES

IMPACT AREA

Livestock exclusions are often not very large and may be measured in its entirety, or may require one stream reach identified and laid out according to the methods described on page 11.

CONTROL AREA

A paired control reach immediately upstream of each project site should be selected and designed in the same manner as the impact reach for each of the projects. Care should be taken that the control area is not subjected to more cattle use due to the exclusion downstream.

PRE-PROJECT SAMPLING

All livestock exclusion projects identified for long term monitoring by the SRFB must have completed pre-project Year 0 monitoring prior to beginning the project. Year 0 monitoring will consist of:

- Determining the extent of use by livestock (high, medium, low).
- Determining the linear distance in kilometers to the nearest tenth of the stream protected by fencing.
- Measure riparian vegetation structure for the project area, including canopy cover and density measurements. The riparian vegetation is divided into three layers, canopy layer (.5m high), understory (0.5 to 5m high), and ground cover (,0.5m high).
- Measure proportion of stream bank at transect locations actively eroding.

POST PROJECT SAMPLING

Upon completion of the project, Years 1, 3, 5, and 10 monitoring will consist of:

- Determine whether the area inside the exclusion has been used by livestock.
- Measure riparian vegetation structure for the project area, including canopy cover and density measurements. The riparian vegetation is divided into three layers, canopy layer (.5m high), understory (0.5 to 5m high), and ground cover (,0.5m high).
- Measure proportion of stream bank at transect locations actively eroding.

METHOD FOR DETECTING PRESENCE/ABSENCE OF LIVESTOCK

PURPOSE

This protocol is used to determine whether the design criteria are met over a ten-year period. The restoration project excludes livestock from the riparian zone in order for the riparian vegetation and stream morphology to recover from the effects of livestock. Therefore, the fence design and strength should continue to exclude livestock for at least ten years.

EQUIPMENT

Prepare for the survey by bringing a quality pair of binoculars, a digital camera, and a "write-in-the-rain" notebook for recording results.

SAMPLING PROCEDURE

Step 1: Walk the length of the fence looking for breaks in the fence and/or evidence of livestock passing through, under, or over the fencing. Photograph any breaks or evidence of livestock activity and note them on the appropriate form.

Step 2: Proceed inside the exclusion area and walk the length of the exclusion looking for the presence of livestock tracks, hair or other signs of recent use being careful to distinguish between deer, elk hair, or other wildlife signs and domestic livestock. Report the same in the notebook and take photographs for reference.

Step 3: If livestock have been using the area, determine the cause, if possible. Does evidence show that the fence is damaged or inadequate under Step 1? Is there evidence that livestock have been purposely or accidentally allowed inside the exclusion through a gate, etc.?

Project Number	Date	Fencing Intact Y/N	Livestock present Y/N	If present what is the cause?

Figure 1. Sample livestock exclusion field sampling form

METHOD FOR LAYING OUT CONTROL AND IMPACT STREAM REACHES FOR WADEABLE STREAMS

Protocol taken from: ***Peck et al. (Unpubl.), pp. 63-65, Table 4-4; Mebane et al. (2003)***

EQUIPMENT

Metric tape measure, surveyor stadia rod, handheld GPS device, 3 - 2 ft. pieces of rebar painted bright orange, engineer flagging tape, waterproof markers

SAMPLING CONCEPT

The concept of EMAP sampling is that randomly selected reaches located on a stream can be used to measure changes in the status and trends of habitat, water quality, and biota over time if taken in a scientifically rigorous manner per specific protocols. We have applied the EMAP field sampling protocols for measuring effectiveness of restoration and acquisition projects. Instead of a randomly selected stream reach, the stream reach impacted by the project is sampled. These “impact” areas have been matched with “control” areas of the same length and size on the same stream whenever possible.

Within each sampled project reach a series of transects A-K are taken across the stream and riparian zone as points of reference for measuring characteristics of the stream and riparian areas. The transects are then averaged to obtain an average representation of the stream reach.

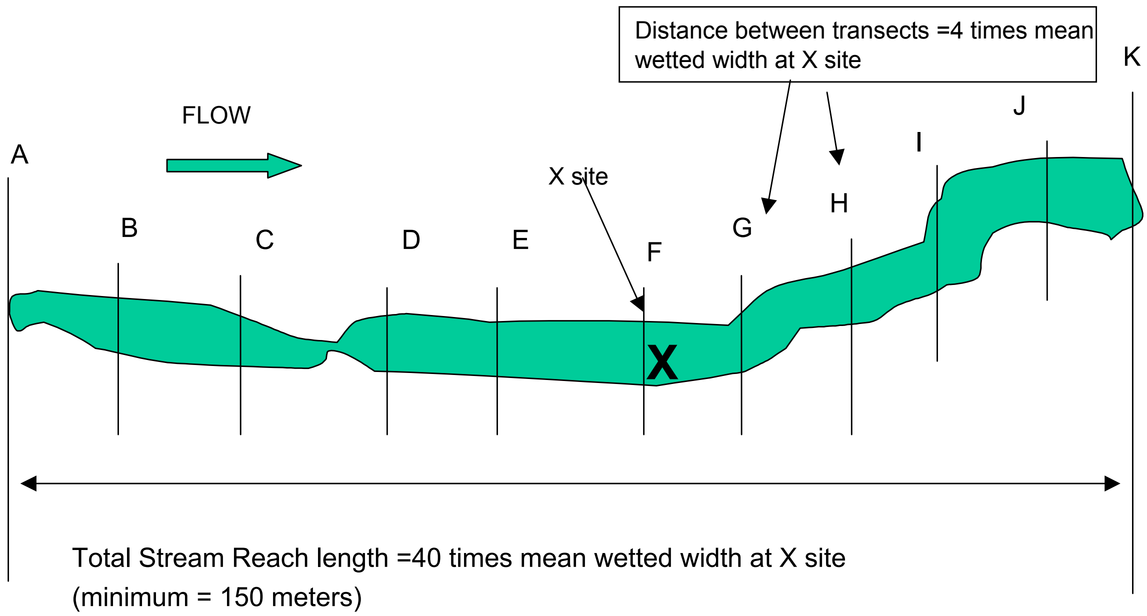

Figure 2. Sampled project reach

LAYING OUT THE TREATMENT AND CONTROL STREAM REACHES

Step 1: Using a handheld GPS device, determine the location of the **X sites** and record latitude and longitude of same on waterproof sheets. The X sites should be considered the center of the impact and control study reach. The impact reach X site must fall within the project affected area. The location of the control X site should be determined based upon the project category and associated procedure (MC-1 to MC-10). Mark the X site on the bank above the high water mark with one of the rebar stakes so that the X site can be found in future years. Use a surveyor's rod or tape measure to determine the wetted width of the channel at five places considered to be of "typical" width within approximately five channel widths upstream and downstream of the X site sample reach location. For streams less than 4 m in width the reach should be at minimum 150 m.

Step 2: Check the condition of the stream upstream and downstream of the X site by having one team member go upstream and one downstream. Each person proceeds until they can see the stream to a distance of 20 times the stream width (equal to one half the sampling reach length) determined in Step 1.

For example if the reach length is determined to be 150 m, each person would proceed 75 m from the X site to lay out the reach boundaries.

NOTE: *For restoration projects less than 40 stream widths, the entire project's length should be sampled and a control area of similar size should likewise be developed within the treatment stream either upstream or downstream as appropriate.*

Step 3: Determine if the reach needs to be adjusted around the X site due to confluences with lower order streams, lakes, reservoirs, waterfalls, or ponds. Also adjust the boundaries to end and begin with the beginning of a pool or riffle, but not in the center of the pool or riffle. Hankins and Reeves (1988) have shown that measures of the variance of juvenile fish populations is decreased by using whole pool/riffles in the sample area.

Step 4: Starting back at the X site, measure a distance of **20 channel widths** down one side of the stream using a tape measure. Be careful not to cut corners. Enter the channel to make measurements only when necessary to avoid disturbing the stream channel prior to sampling activities. This endpoint is the downstream end of the reach and is flagged as transect "A".

Step 5: Using the tape, measure 1/10th (4 channel widths in big streams or 15 m in small streams) of the required stream length upstream from the start point (transect A). Flag this spot as the next cross section or transect (transect B).

Step 6: Proceed upstream with the tape measure and flag the positions of nine additional transects (labeled "C" through "K" as you move upstream) at intervals equal to 1/10th of the reach length.

METHOD FOR CHARACTERIZING RIPARIAN VEGETATION STRUCTURE

Protocol taken from: ***Peck et al. (Unpubl.), Table 7-10; Kauffman et al. (1999)***

PURPOSE

This protocol is designed to determine the changes in riparian vegetation due to a restoration or acquisition project where riparian vegetation has either been planted or has been protected.

EQUIPMENT

Convex spherical densitometer, field waterproof forms.

SITE SELECTION

The sample reaches are those laid out according to the methods on page 11.

SAMPLING DURATION

Sampling should occur during July-August when vegetation is at its maximum growth.

PROCEDURES FOR MEASURING RIPARIAN VEGETATION AND STRUCTURE

Following are taken from Table 7-10 of EMAP protocols:

1. Standing in mid-channel at a cross-section transect (A-K), estimate a 5m distance upstream and downstream (10m length total).
2. Facing the left bank (left as you face downstream), estimate a distance of 10m back into the riparian vegetation or until an exclosure is encountered. On steeply sloping channel margins, estimate the distance into the riparian zone as if it were projected down from an aerial view.
3. Within this 10 m X 10 m area, conceptually divide the riparian vegetation into three layers: a canopy layer (>5 m [16ft] high), an understory (0.5 to 5 m [20 inches to 16ft.] high), and a ground cover layer (<0.5 m high).
4. Within this 10 m X 10 m area, determine the dominant vegetation type for the canopy layer as either **Deciduous, Coniferous, broadleaf Evergreen, Mixed, or None.** Consider the layer mixed if more than 10% of the areal coverage is made up of the alternate vegetation type. Indicate the appropriate vegetation type in the “Visual Riparian Estimates” section of the Channel/Riparian Cross Section Form.
5. Determine separately the areal cover class of large trees (>0.3 m [1ft] diameter breast height [DBH]) and small trees (<0.3m DBH) within the canopy layer. Estimate areal cover as the amount of shadow that would be cast by a particular layer alone if the sun were directly overhead. Record the appropriate cover class on the field data form (**“0”= absent: zero cover, “1”= sparse: <10%, “2”= moderate: 10-40%, “3”=heavy: 40-75%, or “4”= very heavy: >75%)**.
6. Look at the understory layer. Determine the dominant vegetation type for the understory layer as described in Step 4.
7. Determine the areal cover class for woody shrubs and saplings separately from non-woody vegetation within the understory, as described.
8. Look at the ground cover layer. Determine the areal cover class for woody shrubs and seedlings, non-woody vegetation, and the amount of bare ground present as described in Step 5 for large canopy trees.
9. Repeat steps 1 through 8 for the right bank.
10. Repeat steps 1 through 9 for all cross-section transects, using a separate field data form for each transect.

Table 2. Field data form for recording visual riparian estimates. One form for each transect A-K.

Riparian Vegetation Cover	Left Bank					Right bank					Flag
	Canopy (> 5m high)										
Vegetation type	**D**	**C**	**E**	**M**	**N**	**D**	**C**	**E**	**M**	**N**	
Big trees (trunk > 0.3m DBH) XCL	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Small trees (trunk ,0.3m DBH) XCS	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
	Understory (0.5 to 5m high)										
Vegetation type	**D**	**C**	**E**	**M**	**N**	**D**	**C**	**E**	**M**	**N**	
Woody shrubs and saplings XMW	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Non-woody herbs grasses and forbs XMH	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
	Ground cover (,0.5m high)										
Woody shrubs & saplings XGW	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Non-woody herbs grasses and forbs XGH	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Barren dirt or duff XGB	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	

Table 3. Table taken from Kauffman et al. (1999) details the parameter codes and precision metrics of EMAP procedures conducted in Oregon. Parameters in bold type are the most precise. This table is provided for informational purposes to illustrate why certain indicators were chosen for monitoring.

Code	Variable name and description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep}
XCL	Large diameter tree canopy cover (proportion of riparian)	0.057	38	4.6
XCS	Small diameter tree canopy cover (proportion of riparian)	0.12	55	1.4
XC	**Tree canopy cover (proportion of riparian)**	**0.12**	**33**	**2.4**
XPCAN	**Tree canopy presence (proportion of riparian)**	**0.08**	**8.7**	**10**
XMW	Mid-layer woody vegetation cover (proportion of riparian)	0.12	41	0.9
XMH	Mid-layer herbaceous vegetation cover (proportion of riparian)	0.13	100	0.9
XM	**Mid-layer vegetation cover (proportion of riparian)**	**0.19**	**44**	**0.6**
XPMID	**Mid-layer vegetation presence (proportion of riparian)**	**0.03**	**3.5**	**2.1**
XGW	Ground layer woody vegetation cover (proportion of riparian)	0.17	77	0.1
XGH	Ground layer herbaceous vegetation cover (proportion of riparian)	0.16	40	1.1

XGB	Ground layer barren or duff cover (proportion of riparian)	0.07	47	2.0
XG	Ground layer vegetation cover (proportion of riparian)	0.22	36	0
PCAN_C	Conifer riparian canopy (proportion of riparian)	0.11	58	8.5
PCAN_D	Broadleaf deciduous riparian canopy (proportion of riparian)	0.13	31	7.4
PCAN_M	Mixed conifer-broadleaf canopy (proportion of riparian)	0.16	65	2.9
PMID_C	Conifer riparian mid-layer (proportion of riparian)	0.02	55	37
PMID_D	Broadleaf deciduous riparian mid-layer (proportion of riparian)	0.33	58	0.7
PMID_M	Mixed conifer-broadleaf canopy (proportion of riparian)	0.32	87	0.6

PROCEDURES FOR MEASURING CANOPY COVER

Canopy cover is determined for the stream reach in the treatment and control areas at each of the 11 cross section transects. A convex spherical densitometer (Model B) is used. Six measurements are obtained at each cross section transect at mid-channel.

1. At each cross-section transect, stand in the stream at mid-channel and face upstream.
2. Hold the densitometer 0.3 m (1 ft.) above the stream. Hold the densitometer level using the bubble level. Move the densitometer in front of you so that your face is just below the apex of the taped "V".
3. Count the number of grid intersection points within the "V" that are covered by either a tree, a leaf, or a high branch. Record the value (0-17) in the CENUP field of the canopy cover measurement section of the form.
4. Face toward the left bank (left as you face downstream). Repeat steps 2 and 3, recording the value in CENL field of the data form.
5. Repeat steps 2 and 3 facing downstream, and again while facing the right bank (right as you look downstream). Record the values in the CENDWN and CENR fields of the field data form.
6. Repeat steps 2 and 3 again, this time facing the bank while standing first at the left bank, then the right bank. Record the value in the LFT and RGT fields of the data form.
7. Repeat steps 1-6 for each cross-section transect (A-K). Record data for each transect on a separate data form.
8. If for some reason a measure cannot be taken, indicate in the "Flag" column.

Location	1-17	Flag
CENUP		
CENL		
CENDWN		
CENR		
LFT		
RGT		

Figure 3. Densitometer Reading Form

Each of the measures taken at the center of the stream are summed for all 11 transects and converted to a percentage based upon a maximum score of 17 per transect. The results are then averaged to produce a mean % canopy density at mid-stream (XCDENMID).

Each of the measures taken at the banks of the stream are summed for all 11 transects and converted to a percentage based upon a maximum score of 17 per transect. The results are then averaged to produce a mean % canopy density at the stream bank (XCDENBK).

Each of the measures are totaled and averaged to produce the following table of riparian vegetative cover.

Table 4. Canopy density measurement indicators. The shaded composite variables are considered the most important in terms of their precision and are the ones that will be used to determine effectiveness of riparian plantings. CV σ_{rep} / ”(%) is the coefficient of variation. The lower the number, the more precise the measurement S/N = $\sigma^2_{st(yr)} / \sigma^2_{rep}$ is the signal to noise ratio. The higher the number, the more that metric is able to discern trends or changes in habitat in a single or multiple sites. This table is provided for informational purposes to illustrate why certain indicators were chosen for monitoring.

Variable	Description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep}
XCDENBK	Mean % canopy density at bank (Densitometer reading)	3.9	4.4	17
XC DENMID	**Mean % canopy density mid-stream (Densitometer reading)**	**5.8**	**8.1**	**15**
XCM	Mean riparian canopy + mean mid-layer cover	0.22	33	1.4
XPCM	Riparian canopy and mid-layer presence (proportion of reach)	0.08	9.8	7.9
XPCMG	**3-layer riparian vegetation presence (proportion of reach)**	**0.08**	**9.8**	**8.0**

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METHOD FOR MEASURING ACTIVELY ERODING STREAMBANKS

Protocol taken from: ***Moore et al. (1998)***

PURPOSE

The protocol will allow us to determine if the stream banks within the habitat restoration area have improved and thereby reduced siltation and erosion by reducing the percentage of the streambank that is actively eroding.

EQUIPMENT

Appropriate waterproof sampling form, waders or hip boots.

SITE SELECTION

The sample reaches are the same as those laid out according to the methods described on page 11.

PROCEDURE

Estimate the percent of the lineal distance of both sides of the transect that is actively eroding at the active channel height. Active erosion is defined as actively, recently eroding or collapsing banks and may have the following characteristics: exposed soils and inorganic material, evidence of tension cracks, active sloughing, or superficial vegetation that does not contribute to bank stability.

Transect	Left Bank	Right Bank
A		
B		
C		
D		
E		
F		
G		
H		
I		
J		
K		
Total (sum left & right bank)		
Mean Percent erosion (total/22)		
Variance		

Figure 4. Bank erosion form. Percent erosion

TESTING FOR SIGNIFICANCE

We can create a table resembling the following from the data collected for each of the indicators for livestock exclusions (Table 5), canopy cover (Table 6), 3 layer riparian cover (Table 7), and bank erosion.

Table 5. Example of a data table for presence of intact livestock exclusions

	Year 0 2003	Year 1 2005	Year 3 2006	Year 5 2008	Year 10 2014
	Impact	**Impact**	**Impact**	**Impact**	**Impact**
Proj. 1	**No**	**Yes**	**Yes**	**Yes**	**Yes**
Proj. 2	**No**	**Yes**	**Yes**	**Yes**	**Yes**
Proj. 3	**No**	**Yes**	**Yes**	**Yes**	**Yes**
Proj. 4	**No**	**Yes**	**No**	**No**	**No**
Proj. 5	**No**	**Yes**	**Yes**	**Yes**	**Yes**
Proj. 6	**No**	**Yes**	**Yes**	**Yes**	**Yes**
Proj. 7	**No**	**Yes**	**Yes**	**Yes**	**Yes**
Proj 8	**No**	**Yes**	**Yes**	**Yes**	**Yes**
Proj 9	**No**	**Yes**	**Yes**	**Yes**	**Yes**
Proj 10	**No**	**Yes**	**Yes**	**Yes**	**Yes**
% Change	**0**	**100**	**90**	**90**	**90**

Table 6. Mean % canopy density at bank (densitometer reading)

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Impact	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj 8										
Proj 9										
Proj 10										
Sum										
Mean										
Var.										
% Change										

Table 7. 3-layer riparian vegetation presence (proportion of reach)

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Impact	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj 8										
Proj 9										
Proj 10										
Sum										
Mean										
Var.										
% Change										

Among all of the measures taken, two measures (mean percent canopy density at the bank and the three-layer riparian vegetation presence) demonstrate the greatest precision and signal to noise ratio. We wish to test whether these parameters have increased significantly post impact. We also wish to test whether the proportion of the stream bank actively eroding has changed over time.

The data will be tested using a paired *t*-test. The paired *t*-test is a very powerful test for detecting change because it eliminates the variability associated with individual sites by comparing each stream to itself, that is, at upstream and downstream locations within the same stream. The impact reach and control reach for each stream are affected by the same local environmental factors and local characteristics in the species composition and density of vegetation in contrast with other stream systems with their own unique environmental conditions. In other words, the two observations of the pair are related to each other.

Because the paired *t*-test is such a powerful test for detecting differences, very small differences may be statistically significant but not biologically meaningful. For this reason, biological significance will be defined as a 20% increase in mean percent canopy density at the bank and the three layer riparian vegetation presence at the impact sites. The statistical test will be one-sided for an alpha=0.10. We use a one-sided test because a significant decrease in mean percent canopy density at the bank, the three layer riparian vegetation presence, and bank erosion after the impact would not be considered significant, that is, the project would not be considered effective. Therefore, we are not interested in testing for that outcome. The test will be conducted in Years 1, 3, 5, and 10. If the results are significant in any of those years, the livestock exclusion projects will be considered effective.

Our conclusions are, therefore, based upon the differences of the paired scores for the ten sampled livestock exclusion projects. Though somewhat confusing, it may be helpful to think of the statistic as the “difference of the differences”. A one-tailed paired-sample *t*-test would test the hypothesis.

H_0 : The mean difference is less than or equal to zero.
H_A : The mean difference is greater than zero.

The test statistic is calculated as:

$$t_{n-1} = \frac{đ - 0}{S_{đ}}$$

where
$\underline{đ}$ = mean of the differences for Year 0 and a subsequent year

$S_{đ}$ = variance of the differences

$S_{đ} = S_d / n^{1/2}$ = variance mean

n = number of sites (or site pairs).

DATA MANAGEMENT PROCEDURES

Data will be collected in the field using various hand-held data entry devices. Raw data will be kept on file by the project monitoring entity. A copy of all raw data will be provided to the SRFB at the end of the project. Summarized data from the project will be entered into the PRISM database after each sampling season. The PRISM database contains data fields for the following parameters associated with these objectives.

Table 8. Category 1 Livestock Exclusion Projects

Indicator	Metric	Pre impact Year 0	Post impact Year 1	Post impact Year 3	Post impact Year 5	Post impact Year 10
Stream distance affected by exclusion	Miles	√				
Total area affected	Acres	√				
Livestock present	Yes/No	√	√	√	√	√
Level 1 effective	Yes/No		√	√	√	√
Riparian shade impact	Mean % canopy density at the bank	√	√	√	√	√
Riparian shade control	Mean % canopy density at the bank	√	√	√	√	√
Statistically significant	Yes/No			√	√	√
Riparian cover impact	Proportion of impact reaches where 3 vegetation layers are present	√	√	√	√	√
Riparian cover control	Proportion of control reaches where 3 vegetation layers are present	√	√	√	√	√
Eroding banks Impact	Proportion of banks actively eroding					
Eroding banks control	Proportion of banks actively eroding					
Level 2 effectiveness	Yes/No		√	√	√	√

REPORTS

PROGRESS REPORT

A progress report will be presented to the SRFB in writing after the sampling season for Year 1, 3, and 5.

FINAL REPORT

A final report will be presented to the SRFB in writing after the sampling season for Year 10. It shall include:

- Estimates of precision and variance.
- Confidence limits for data.
- Summarized data required for PRISM database.
- Determine whether project met decision criteria for effectiveness.
- Analysis of completeness of data, sources of bias.

Results will be reported to the SRFB during a regular meeting after 1, 3, 5, and 10 years post-project. Results will be entered in the PRISM database and will be reported and available over the Interagency Committee for Outdoor Recreation web site and the Natural Resources Data Portal.

ESTIMATED COST

It is estimated that approximately 37 hours per project would be required to conduct all field activities under the protocol. This results in a relative 2004 cost of $2,300-$3,800 per project.

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